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A Discussion on an Efficient Virtual Traffic Control System for Un-Trackable City Vehicles

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Abstract

In this paper, we present an efficient virtual traffic control system for un-trackable city vehicles. The protocol handling the traffic control of the system sits on a distributed metropolitan vehicle message exchange platform. By employing GPS/DTD(GPRS) coordinating system support, the virtual message exchange system introduced in this paper can be used to not only secure un-trackable city vehicles, but also dispatch cabs.

Keywords: GPS; GPS/DTD (GPRS) communication; vehicle security control protocol; un-trackable vehicle; wireless vehicle dispatching; taxi or cab dispatching

1.Introduction

Accompanied with city development in China, more and more people prefer to live and work in big cities of China. Today, a big city in China (such as Beijing) could hold tens of million people. And, these people have diverse living/working styles, cultures, and education statuses. So, to construct a harmonious society in big cities of China could be a great feat in Chinese history. Its difficulty is obvious. Since "September 11" attack in USA, terrorist activity comes one after another. It seems like that the successful attack in USA becomes a model to follow (for example, the number of air-crash accidences after "September 11" adds up to the sum of previous decades). This reminds us that, during the merging process of different cultures, due to the experiences, history, and education level of the people, the society that we are living still more or less has hidden troubles. Today, different countries deployed their study in building anti-terror weapons. And the power of these conventional weapons could lead to a local war in deserted areas. However, for a dense population area, these weapons could cause huge damage and calamity. So, in this case, protection measure becomes more projective. In the analysis of terrorist activity of recent years, their targets were mostly focused on vehicles, public areas, and buildings. So, in the following, our discussion will be focused on constructing security measure on vehicles.

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In today's metropolitan areas, the transporting vehicles include: bus, heavy truck, car, train, airplane etc... According to their mobility, these vehicles could be categorized into trackable vehicles and un-trackable vehicles. Those trackable vehicles include: city bus, subway, train and airplane. And the left are defined as un-trackable. Normally, in the study of a metropolitan traffic system, the most attractable traffic fluxes are generated by cars, trucks and buses running on the metropolitan roadways.

In china, the security measures, such as monitors, alarming systems, and recorders, are set up on most tractable vehicles. Security guards also patrol on trains and airplanes. However, for those un-trackable vehicles, security measures are seldom considered. Most security components were optional when a vehicle was sold out. However, these un-trackable vehicles occupy major traffic of the metropolitan roadway. Thus, the roadway security hidden problems are majorly caused by un-trackable vehicles. But, how can we take measures to protect these vehicles?

Nowadays, GPS/GPRS coordinating system was applied in different security related areas such as: fire fighting, children cell-phone, emergency rescue, etc… Thus, we can still use this sort of systems to protect un-trackable vehicles. Meanwhile, the system can also provide real-time traffic information for drivers. Traversers on the opinion for building GPS/GPRS security system on a normal car are mostly concerning on the privacy problem that could be produced by GPS/GPRS security system. However, their worry is useless. Like internet (every body uses it, they even pay online), GPS/GPRS security system can be controlled by national safety system, so, it is trustable.

In general, contemporary GPS related vehicle control systems are mostly used by cab dispatching (or simple cab calling center). And this sort of systems was used separately by different cab companies without cooperation. Thus, their registered vehicle data are not sharable. Moreover, since the service of the cab calling center is manually controlled, so, at traffic time, people should wait online for a service specialist. Some dispatching system was designed on a paging system [1], which was already obsolete in China. The system design in [2] was an interactive cab dispatching system, but it is not a real-time design. The design in [3] and an AVLDS (Automatic Vehicle Location and Dispatch System) mentioned in [4] was automatic real-time dispatching system, but their application in China still needs more modifications. Moreover, the above cab dispatching system designs lack of security control. Thus, to apply them in China as vehicle security system, there still needs more modifications.

In the following of this paper, we present a virtual system based on GPS/Data Transfer Device (DTD, such as GPRS or any long distance wireless communication link) coordinating system to protect un-trackable vehicles, to relieve traffic power, and to efficiently dispatch rental vehicles.

2.System Model

2.1.Architecture of Virtual System

The virtual system generally includes three components: 1) GPS/DTD installed on a vehicle; 2) traffic control center; and 3) information exchange center. We further assume that:

- Every vehicle (including private car, cab, and rental car) was equipped with GPS/DTD.
- Every district area inside a city was equipped with traffic control center.
- The traffic information of above traffic control centers can be exchanged.

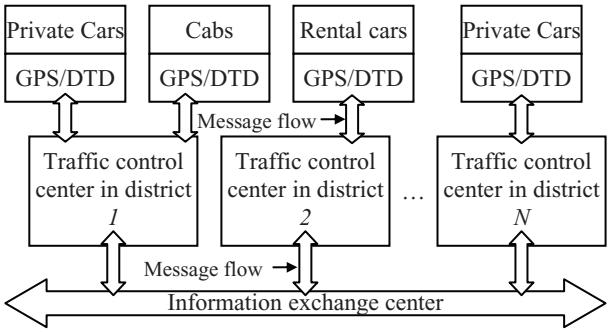

Figure 1. The virtual system

With the above assumption, we have a system model configured as shown in Fig. 1. The security messages exchanged between traffic control center and its registered vehicles, and between traffic control centers located in different city districts are defined in three types:

- Up-link message (from GPS/DTD to traffic control center):
  It primarily encapsulates the information of the vehicle: 1) GPS coordinates (used for traffic control center to locate the vehicle); and 2) encoded license plate number plus registration number (used for traffic control center to identify the vehicle). Moreover, 3) alarm messages as well as 4) passenger load information (such as number of passengers, and the hotel name or location name etc…) of cabs or rental cars can be also encapsulated. The first two encapsulated data of a specific vehicle are sent to traffic control center regularly between time intervals.
- Down-link message (from traffic control center to GPS/DTD):
  It encapsulates: 1) control message to stop the vehicle (this message should be only controlled by police traffic control center after the report or confirmation of a stolen car); 2) real-time traffic information (this information could be used by the car to calculate the optimal path, thus avoid traffic jam, and probability of a car accident); and 3) statistical passenger load information of different district areas for cabs to make their choice to find a job (this could automatically dispatch cabs on their way to work, we will discuss this later).
- Exchange message (between traffic control centers):
  It encapsulates: 1) query information of a registered vehicle; 2) passenger load information from a specific district area; and 3) real-time traffic information of a specific district area.

2.2.GPS/DTD

This device is installed on every vehicle or any place (such as hotel or railway station etc…) needed to: 1) send Up-link messages to traffic control center to report its GPS location and its identity; and 2) receive Down-link messages to: a) stop the vehicle in case of theft; b) calculate optimal path for travel; and c) to seek a passenger on require (this is only used by cabs or rental cars).

2.3.Traffic Control Center

The traffic control center generally includes the following three systems:

- Calling Center:
  It is primarily in charge of two major works: 1) accepts alarm messages, and reports to emergency response system to tackle the problem; 2) automatically dispatches cabs or rental cars to seek their passenger load.
- GPS Coordinating Center:

This center is used to: 1) calculate the traffic information on different roads in its own city district and send the information to each vehicle located on each road; 2) locate and trace a specific vehicle; 3) cooperate with calling center to send passenger load probability information to cabs in different road of its own district area; 4) cooperate with calling center to dispatch cabs; and 5) cooperate with calling center to send control message to a reported stolen vehicle to stop it.

- Registration database:
  The system records the basic information (such as license plate number and registration number) of every vehicle registered inside its district area. And its information is shared with other traffic control centers through information exchange center.

2.4.Information Exchange Center

This platform is used to exchange traffic information between different city district areas (or traffic control centers). Primarily, three types of messages are exchanged on this platform: 1) vehicle registration information (license plate number plus registration number); 2) vacant information of cabs for cab dispatching in different district areas; and 3) GPS Up-link messages.

3.Protocol Discussion

In the following, we present protocols to use the virtual system to protect un-trackable vehicles and dispatch cabs.

3.1.In Vision of a Suspicious Vehicle

As shown in Fig. 2, when a police man finds a suspicious vehicle, he will follow the following protocol to trace the vehicle.

- Send a message to calling center with the vehicle's license plate number;
- The calling center will query its own registration database to see whether the license plate number was a registered one. If it is not a locally registered license plate number, go to step 3. If the number was registered locally, go to step 4.
- Transfer the query to information exchange center to find a result. If there's not such a registered plate number (sometimes the license plate number is fake.) in other district areas (or traffic control center), go to step 7; if the plate number is registered, go to step 4.
- Return query result (the result will include license plate number and registration number).
- Send query result to GPS coordinating center and ask GPS coordinating center to start tracing the suspicious vehicle.
- GPS coordinating center will match the query result with Up-link message (the license plate number and the registration number of the vehicle recorded in GPS/DTD) of the vehicle. If the match fails, go to step 7, otherwise go to step 8.
- Tell the police the match fails, and let him trace the vehicle.
- Start automatic GPS tracing.

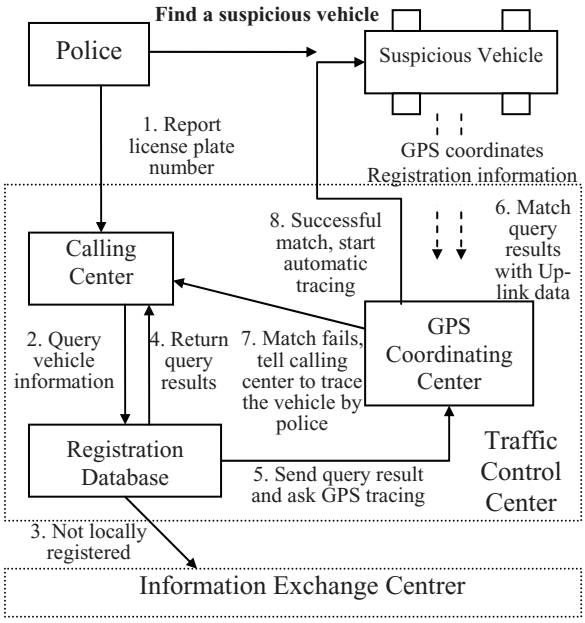

Figure 2. In vision of a suspicious vehicle

3.2.Stop a Stolen Car

As shown in Fig. 3, when a vehicle owner found that his vehicle was stolen, he can follow the following steps to stop his stolen vehicle and coordinate it.

- Send a message to calling center with the vehicle's license plate number;
- The calling center will query its own registration database to see whether the license plate number was a registered one. If it is not a locally registered license plate number, go to step 3. If the number was registered locally, go to step 4.
- Transfer the query to information exchange center to find a result.
- Return query result (the result will include license plate number and registration number).
- Send query result to GPS coordinating center and ask GPS coordinating center to start tracing the stolen vehicle.
- GPS coordinating center will match the query result with Up-link message (the license plate number and the registration number of the vehicle recorded in GPS/DTD) of every vehicle in this city district area. If the match fails, go to step 7, otherwise go to step 8.
- Broadcast the stolen vehicle's information to other GPS coordinating centers through information exchange center, and let any of them find the stolen vehicle and go to step 8.
- Tell the calling center that holds the owner's report the vehicle was found.
- The calling center will let the owner know and ask GPS coordinating center to stop the vehicle.
- GPS coordinating center send Down-link message to the stolen vehicle to stop it.

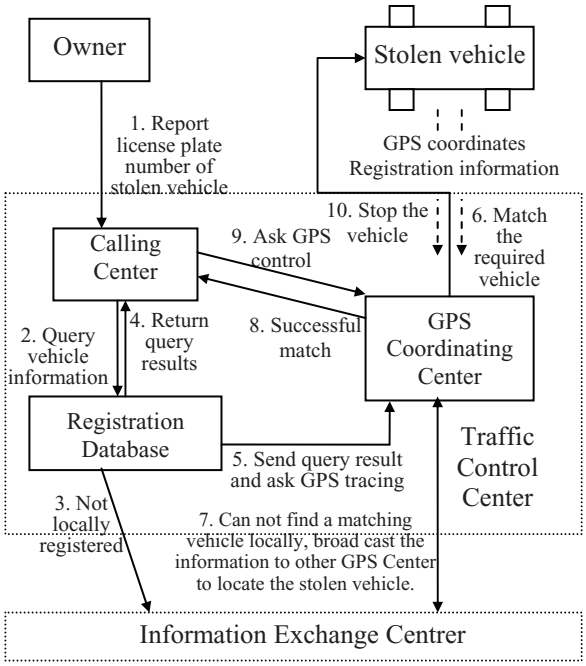

Figure 3. To stop a stolen vehicle

3.3.Dispatch Cabs

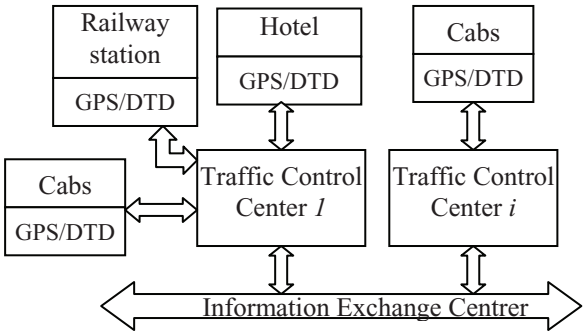

Figure 4. Cab dispatching model

Fig. 4 shows system model for cab dispatching inside a metropolitan area. We assume that public places such as railway station and hotel are equipped with GPS/DTD. Thus, the passenger could use GPS/DTD terminal installed in railway station or hotel to send messages to traffic control center to automatically locate a cab for service. The detailed protocol for this cab dispatching service is listed as follows (Fig. 5):

- When passenger (*1, 2…, i…, n*) at airport, railway station, or hotel wants a cab, they just need to send their request through GPS/DTD terminal installed in their place and wait for dispatched cabs.
- When the calling center received their requests, these requests are pushed in a first in and first serve (FIFS) queue.

- Launch each request to GPS coordinating center one by one.
- GPS coordinating center searches its recorded vehicle location cache for a vacant cab nearest to the passenger asking for the request. If there is one (or the cab's status is "vacant"), go to step 6, otherwise,
- Broadcast the passenger's request to other traffic control centers nearest to the passenger's location through information exchange center, and wait for a nearest traffic control center who can handle the request sending back its service information (such as the cab's license plate number, driver's cell phone number etc…). Go to step 7.
- Communicate with the cab driver through GPS/DTD terminal to see whether or not he can provide the service, if not, go to step 4. Otherwise, label the cab's status as "in service", and,
- If the request is a broadcast request from other traffic control centers, send the service information back to that traffic control center. Otherwise, send the service information to the calling center directly and let the passenger know that his request is in service.

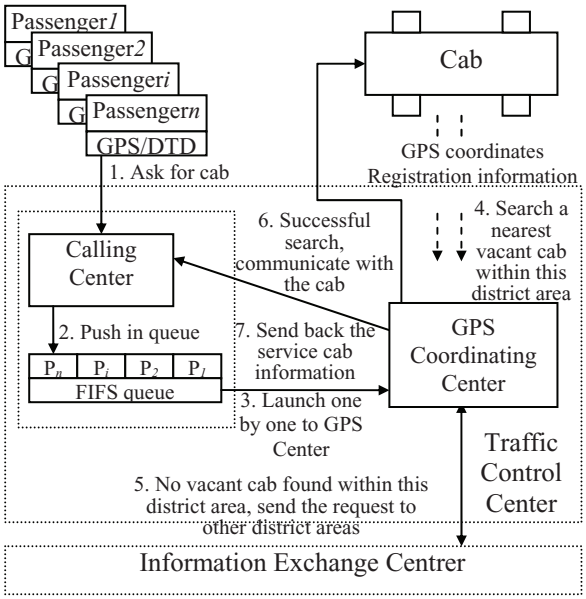

Figure 5. Cab dispatching protocol

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